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Cost-Effectiveness Analysis of Proposed Effluent Limitations Guidelines and Standards for the Metal Products and Machinery Industry

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Cost-Effectiveness Analysis

Introduction

This cost-effectiveness analysis supports the proposed effluent limitations guidelines and standards for the Metal Products and Machinery (MP&M) Industry. The report assesses the cost-effectiveness of three regulatory options for indirect dischargers, which discharge effluent to publicly-owned treatment works (POTWs), and direct dischargers, which discharge effluent directly to a surface water.

Cost-effectiveness analysis is used in the development of effluent limitations guidelines to evaluate the incremental efficiency of different regulatory options. Cost-effectiveness is traditionally defined as the incremental annual cost (in 1981 constant dollars) per incremental toxic-weighted pound of pollutant removed. This definition includes the following concepts:

❖ ***Toxic-weighted removals***

Because pollutants differ in their toxicity, the reductions in pollutant discharges, or pollutant removals, are adjusted for toxicity by multiplying the estimated removal quantity for each pollutant by a normalizing weight, called a ***toxic weighting factor*** **(TWF)**.[1] The TWF for each pollutant measures its toxicity relative to copper, with more toxic pollutants having higher TWFs. The use of toxic weights allows the removals of different pollutants to be expressed on a constant toxicity basis as toxic pound-equivalents (lb-eq). The weighted quantities removed for the different pollutants may then be summed to yield an aggregate measure of the reduction in toxicity-normalized pollutant discharges that is achieved by a regulatory option.

The cost-effectiveness analysis focuses on toxic pollutants in MP&M facility dischargers to surface waters. The analysis does not address the removal of ***conventional pollutants*** (***oil and grease***, ***biochemical oxygen demand*** **(BOD)**, and ***total suspended solids*** **(TSS)**), nor does it address the removal of bulk parameters, such as chemical oxygen demand (COD). Although EPA has accounted for reductions to pollutants loadings due to treatment at ***publicly-owned treatment works*** **(POTWs)**, the cost-effectiveness analysis does not address routes of potential environmental damage and human exposure other than via surface waters, such as POTW inhibition problems and contamination of POTW biosolids (sewage sludge.)

The cost-effectiveness ratio considers reductions in loadings from two sources:

- facilities that undertake pollution prevention and waste water treatment to comply with the rule, and
- facilities that close as a result of the rule.

Loadings eliminated by baseline closures (i.e., MP&M facilities that are projected to close even if there is no MP&M regulation) are not attributed to the rule and are not considered in the analysis.

❖ ***Annual costs***

The cost-effectiveness analysis uses the estimated annual costs of complying with the alternative regulatory options. The annual costs include annual expenses for operating and maintaining compliance equipment and for meeting monitoring requirements, and the annualized cost of capital outlays for pollution prevention and treatment systems. These costs are calculated on a pre-tax basis (i.e., without any adjustment for tax treatment of capital outlays and operating expenses), using an assumed opportunity cost of capital of 7 percent.

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[1] The following formats are used in this document as an aid to readers:

glossary: a term defined in the glossary section

acronym: included in the acronym list

Compliance costs are calculated in 1981 dollars to allow for comparison with cost-effectiveness values for regulations developed at different times for different industries. This analysis maintains this practice for comparability, but also presents cost-effectiveness results in 1999$.

EPA does not include any costs for facilities that close due to the rule in the traditional cost-effectiveness calculation. Appendix A provides an alternative calculation that attributes costs to facilities that close due to the rule equal to the compliance costs they would have incurred if they instead continued to operate. This calculation overstates costs because these facilities are expected to find it more economic to shut down rather than incur the compliance costs. No costs or loadings reductions from facilities that close in the baseline are included in the analysis.[2]

❖ ***Incremental calculations***

The incremental values that are calculated for a given option are the change in total annual compliance costs and the change in removals from the next less stringent option, or the baseline if there is no less stringent option, where regulatory options are ranked by increasing levels of toxic-weighted removals. Thus, the cost-effectiveness values for a given option are relative to another option, or, for the least stringent option, to the baseline.

The result of the cost-effectiveness calculation represents the unit cost of removing the next pound-equivalent of pollutants. Cost-effectiveness is strictly a relative measure used for comparative purposes. This analysis does not provided an absolute scale by which a particular cost-effectiveness value can be assigned a qualitative judgment. Because cost-effectiveness values for different rules are expressed in the same year dollars per pound-equivalent removed, cost-effectiveness values for a given option may be roughly compared with those of other options being considered for a given regulation and also with those calculated for other industries in past regulations. Comparisons with CE values for past regulations are only somewhat approximate because scientific and engineering information changes over time. Thus, the estimated POTW removals, toxic weights, and treatment process removals may be quite different for the same pollutants in regulations that are developed in different years.

Although not required by the Clean Water Act, cost-effectiveness analysis is a useful tool for evaluating options for the removal of toxic pollutants. It is not intended to analyze the removal of conventional pollutants, however, such as oil and grease, chemical oxygen demand and total suspended solids, and removals of these pollutant are not included in the cost-effectiveness calculation.

[2] Chapter 5 of the *Economic, Environmental, and Benefit Analysis* document discusses baseline closures.

The remaining parts of this report are organized as follows. Section 1 defines cost-effectiveness, discusses the cost-effectiveness methodology, and describes the relevant regulatory options. Section 2 presents the findings of the separate analyses for direct dischargers and for indirect dischargers. Section 3 compares the cost-effectiveness of the proposed regulation with the cost-effectiveness values calculated for previously promulgated rules. Section 4 lists the pollutants of concern, their CAS numbers, the Toxic Weighting Factor (TWF) for each pollutant, and the Publicly Owned Treatment Work (POTW) removal efficiencies used in this analysis. These removal efficiencies are the percentage of each pollutant that a typical POTW is expected to remove from indirect facility discharges. Appendix A presents an alternative measure of cost-effectiveness, which includes costs for facilities that close due to the rule.

1 METHODOLOGY

1.1 Overview

Three factors are of particular importance in the calculation and use of cost-effectiveness values:

- normalizing pounds of pollutant removed to copper-based toxic pounds-equivalent;
- calculating cost-effectiveness on an incremental basis; and
- use of CE values for comparison rather than on an absolute basis.

First, the analysis is based on removals of pounds-equivalent — a pound of pollutant weighted by its toxicity relative to copper. These toxic weighting factors are based on comparisons with copper, because it is a toxic metal commonly released in industrial effluent. By expressing removals in common terms, EPA can sum across pollutants to compare cost-effectiveness results among alternative regulatory options or different regulations.

Cost-effectiveness analysis is done on an incremental basis to compare the incremental or marginal cost and removals of one control option to another control option or to existing treatment. It, therefore, measures the cost-effectiveness of more stringent controls in a step-wise comparison. In contrast, calculating average (rather than incremental) CE would show the cost per toxic pound removed for an option relative to the baseline, rather than relative to the next less stringent option.

There are no absolute scales for judging CE values as indicating that an option is "cost-effective" or "not cost-effective." The values are considered comparatively high or low only within a given context, such as similar discharge status or compared to effluent limitations guidelines for other industries.

Cost-effectiveness analysis includes the following steps:

- Determine the relevant wastewater pollutants;
- Estimate the relative toxic weights of priority and other pollutants;
- Define the pollution control or regulatory approaches;
- Calculate pollutant removals for each control or regulatory option;
- Determine the annualized cost of each control or regulatory option;
- Rank the options by increasing stringency and cost;
- Calculate incremental cost-effectiveness values; and
- Compare cost-effectiveness values.

These steps are discussed below.

❖ *Pollutant discharges considered in the cost-effectiveness analysis*

Pollutants are selected for analysis based on their toxicity, frequency of occurrence, and amount of pollutant in the waste stream. This cost-effectiveness analysis is based on 132 of the 150 pollutants of concern listed in Section 4.

❖ *Relative toxic weights of pollutants*

EPA has developed toxic weighting factors (TWFs) for a range of pollutants. A higher TWF indicates a more toxic pollutant. For example, a pound of nickel (TWF=0.11) in an effluent stream has significantly less potential effect on human health and aquatic life than a pound of cadmium (TWF=2.6).

In the majority of cases, toxic weighting factors are derived from both chronic freshwater aquatic criteria (or toxic effect levels) and human health criteria (or toxic effect levels) for the consumption of fish. These factors are then standardized by relating them to copper. The resulting toxic weighting factors for each pollutant are provided in Section 4. Table 1 shows some examples of the effects of different aquatic and human health criteria on weighting factors.

Table 1: Weighting Factors Based on Copper Freshwater Chronic Criteria

Pollutant	Human Health Criteria[a] (g/l)	Aquatic Chronic Criteria (g/l)	Weighting Calculation	Toxic Weighting Factor
Copper[b]	1,200	9.0	5.6/1,200 + 5.6/9.0	0.63
Hexavalent Chromium	1,000,000	74.0	5.6/1,000,000 + 5.6/74.0	0.076
Nickel	4,600	52.0	5.6/4,600 + 5.6/52	0.11
Cadmium	84	2.2	5.6/84 + 5.6/2.2	2.6
Benzene	710	530	5.6/710 + 5.6/530	0.018

Criteria are maximum contamination thresholds. Using the above calculation, the higher the thresholds, the lower the toxic weighting factor. Units for criteria are micrograms of pollutant per liter of water.
a. Based on ingestion of 6.5 grams of fish per day.
b. While the water quality criterion for copper has been revised (to 9.0 g/l), the cost-effectiveness analysis uses the old criterion (5.6 g/l) to facilitate comparisons with cost-effectiveness values for other effluent limitations guidelines. The revised higher criteria for copper results in a toxic weighting factor for copper that is not equal to 1.0 but equal to 0.63. This value is used in the analysis to reflect the new estimates of copper toxicity, while still maintaining a scale that enables comparison with earlier CE analyses.
Source: U.S. EPA analysis.

As indicated in Table 1, the toxic weighting factor is the sum of two criteria-weighted ratios: the “old” copper criterion divided by the human health criterion for the particular pollutant, and the “old” copper criterion divided by the aquatic chronic criterion. For example, using the values reported in Table 1, 4.13 pounds of copper pose the same relative hazard in surface waters as one pound of cadmium, since cadmium has a toxic weight 4.13 times (2.6/0.63 = 4.13) as large as the toxic weight of copper.

1.2 Regulatory Options

The regulatory options considered by EPA for the MP&M effluent guidelines are described in detail in the preamble accompanying the proposed rule and in Chapter 4 of the Economic, Environmental, and Benefit Analysis document. This section provides a brief summary of the technology and regulatory options.

EPA selected subcategories within the MP&M industry based on similarity in effluent and economic characteristics. The subcategories differ in part based on the type of wastewater facilities discharge, including facilities that discharge wastewaters with high metals content (with or without oil and grease) and facilities that discharge wastewaters containing primarily oil & grease, with limited metals. The subcategories identified by EPA in each group are:

Metal-bearing (with or without oil & grease):

- Non Chromium Anodizing
- Metal Finishing Job Shops
- Printed Wiring Board
- Steel Forming & Finishing
- General Metals

Oil-bearing only:

- Shipbuilding Dry Docks
- Railroad Line Maintenance
- Oily Waste

EPA evaluated 10 technology options that might be used to treat wastes from the MP&M facilities. Table 2 lists these technology options:

Table 2: Technology Options

Option #	Description
For metal-bearing wastes	
1	segregation of wastewaters, preliminary treatment (including oil-water separation), chemical precipitation, and sedimentation using a clarifier (chemical precipitation with gravity clarification)
2	in-process flow control and pollution prevention + option 1
3	segregation of wastewaters, preliminary treatment (including oil removal by ultrafiltration), chemical precipitation, and solids separation using a microfilter
4	in-process flow control and pollution prevention + option 3
For oil-bearing wastes	
5	oil-water separation by chemical emulsion breaking
6	in-process flow control and pollution prevention + option 5
7	oil-water separation by ultrafiltration
8	in-process flow control and pollution prevention + option 7
9	oil-water separation by dissolved air flotation (DAF)
10	in-process flow control and pollution prevention + option 9

Source: U.S. EPA analysis.

The even-numbered options add in-process flow controls and pollution prevention (pollution prevention, recycling and water conservation to allow recovery and reuse of materials) to the treatment technologies specified in the odd-numbered options. In all cases, options with in-process flow control and pollution prevention cost less and remove more pollutant than the comparable option without pollution prevention. Therefore, this document analyzes only the even-numbered options with flow control and pollution prevention.

EPA selected ***Best Practicable Control*** **(BPT)** technologies for direct dischargers in each subcategory based on the average of the best performances within the industry of various ages, sizes, processes and other characteristics. EPA also considered the cost of these treatment technologies relative to the effluent reductions achieved, to assess the cost-reasonableness of these limitations. EPA then considered application of the ***Best Available Technology Economically Achievable*** **(BAT)**. The Agency is proposing BAT equivalent to BPT for all subcategories except Railroad Line Maintenance and Shipbuilding Dry Docks, for which EPA is not proposing BAT limitations.

EPA evaluated ***Pretreatment Standards for Existing Sources*** **(PSES)** for indirect dischargers by evaluating whether pollutants would "***pass through***" POTWs and whether a combination of POTW treatment and the PSES standards would achieve limitations equivalent to those required for direct dischargers. The same 10 technologies were considered for BPT and for PSES. (See the *Technical Development Document* for a discussion on the pass-through analysis.)

The Agency also considered a range of low flow exclusions for indirect dischargers, to reduce burdens on permitting officials and reduce the economic impacts of the rule. Evaluation of the low flow cutoffs also considered the amount of pollutant discharged by each subcategory and flow size category.

Table 3 lists the technology options and exclusions proposed
for the MP&M effluent guidelines, along with two other regulatory options considered by EPA for this rule-making. These options include:

- Option 2/6/10, which applies the same technologies for each subcategory, and eliminates the low-flow and subcategory exclusions of the proposed rule.

- Option 4/8, which applies more stringent technology requirements for all subcategories and does not include low-flow exclusions.

Table 3: Regulatory Options Considered in the Cost-Effectiveness Analysis

Subcategory	Proposed rule	Option 2/6/10	Option 4/8
General Metals	Technology option 2; 1 MGY flow cutoff for indirect dischargers	Technology option 2	Technology option 4
Metal Finishing Job Shop	Technology option 2	Technology option 2	Technology option 4
Non-Chromium Anodizing	Technology option 2; no PSES/PSNS for indirect dischargers	Technology option 2	Technology option 4
Printed Wiring Board	Technology option 2	Technology option 2	Technology option 4
Steel Forming & Finishing	Technology option 2	Technology option 2	Technology option 4
Oily Waste	Technology option 6; 2 MGY flow cutoff for indirect dischargers	Technology option 6	Technology option 8
Railroad Line Maintenance	Technology option 10; no PSES/PSNS for indirect dischargers	Technology option 10	Technology option 8
Shipbuilding Dry Dock	Technology option 10; no PSES/PSNS for indirect dischargers	Technology option 10	Technology option 8

Source: U.S. EPA analysis.

Technology options 1, 3, 5, 7 and 9 (without pollution prevention) were not further analyzed, because they remove fewer pollutants and cost more than the comparable technology options with pollution prevention.

1.3 Pollutant Removals

EPA calculated the reductions in pollutant loadings to the receiving water body for each regulatory option. ***At-stream*** and ***end-of-pipe*** pollutant removals may differ because a portion of the end-of-pipe loadings for indirect dischargers may be removed by a POTW. As a result, the at-stream removal of pollutants due to PSES regulations are less than end-of-pipe removals. The cost-effectiveness analysis is based upon removals at-stream, as shown in the following example calculation:

Baseline facility discharge of pollutant x to POTW:	100 lbs
POTW removal of pollutant x:	40%
Baseline discharge to surface water:	60 lbs
Reduced facility discharge due to the rule:	30 lbs
Post-rule discharge to POTW:	70 lbs
POTW removal (40%):	28 lbs
Post-rule discharge to surface water:	42 lbs
Reduced loading to surface water due to the rule:	18 lbs

In general, at-stream loadings for facilities that discharge to a POTW are calculated by multiplying end-of-pipe loadings by (1 - POTW removal efficiency). In this example, a reduction of 18 lbs in loadings to surface waters would be included in the cost-effectiveness calculation.

Because the cost-effectiveness analysis reflects changes in at-stream loadings, it does not address other environmental concerns such as POTW ***interference*** problems, or the quantities of pollutants transferred to ***biosolids*** (i.e., sewage sludge) as a result of being removed from the water by the POTW.

1.4 Annualized Costs

Full details of the methods by which the costs of complying with the regulatory options were estimated can be found in the Technical Development Document and the Economic, Environmental, and Benefit Assessment Report. A brief summary of the compliance cost analysis is provided below.

Two categories of compliance costs were included in the cost-effectiveness analysis:

- capital costs, and
- operating and maintenance (O&M) costs (including monitoring costs.)

Although O&M costs occur annually, capital costs are one-time "lump sum" costs. To express the capital costs on a annual basis, capital costs were annualized over the expected useful life of the capital equipment, 15 years, at an opportunity cost of capital of 7 percent.

Total annualized costs are the sum of annualized capital costs and the annual operating and maintenance costs. The cost-effectiveness analysis presented here uses pre-tax costs as the basis for its calculations. Thus, these costs may be interpreted as the cost to society of the facility-level actions taken to comply with the MP&M regulatory options. Appendix A presents an alternative version of cost-effectiveness performed with after-tax costs in the appendix. This represents the incremental cost to industry of each additional pound removed.

Compliance costs were originally calculated in 1996 dollars, the base year of the MP&M industry regulation analysis. The compliance costs are reported in 1999 dollars. They were inflated using *Engineering News Record*'s Construction Cost Index **(CCI)**. For comparing cost-effectiveness values of the options under review to those of other promulgated rules, the compliance costs used in the cost-effectiveness analysis were also deflated from 1999 to 1981 dollars using the CCI. This adjustment factor is:

$$Adjustment\ factor = \frac{1981\ CCI}{1999\ CCI} = \frac{3535}{6060} = 0.583$$

1.5 Ranking Options

The regulatory options were ranked to determine relative cost-effectiveness. Options were first ranked in increasing order of stringency, where stringency is aggregate pollutant removals, measured in pounds-equivalent. If two or more options remove equal amounts of pollutants, these options would then be ranked in increasing order of cost. For example, if two or more options specify zero discharge, the removals under each option would be equal. The options would then be ranked from least expensive to most expensive. There were no cases in the MP&M analysis where an option had the same removals but higher costs than the next less-stringent option.

1.6 Incremental Cost-Effectiveness

EPA calculated incremental cost-effectiveness values for the options ranked by increasing stringency. Cost-effectiveness values were calculated separately for indirect and direct dischargers. For each discharger category, the cost-effectiveness value of a particular option is calculated as the incremental annual cost of that option divided by the incremental pounds-equivalent removed by that option:

$$CE_k = \frac{ATC_k - ATC_{k-1}}{PE_k - PE_{k-1}}$$

where:

CE_k	=	Incremental cost-effectiveness of option k relative to option k-1,
ATC_k	=	Total annualized compliance cost under option k; and
PE_k	=	Removals in pounds-equivalent under option k.

When k corresponds to the least stringent option (k = 1), the incremental costs and removals are the increments in moving from the baseline case to Option k.

2 Results

2.1 Indirect Dischargers

Table 4 summarizes the cost-effectiveness analysis results for the PSES regulatory options applicable to indirect dischargers. Annual compliance costs are shown in 1999 dollars, as reported in the EEBA, and in 1981 dollars. The regulatory options are listed in order of increasing stringency on the basis of the estimated toxic-weighted pollutant removals. Costs presented here do not include costs for facilities that close in the baseline or close due to the technology option being analyzed. Therefore, these costs will not be the same as the engineering costs presented in the MP&M *Technical Development Document*.

Table 4: Cost-Effectiveness for Indirect Dischargers (PSES)

Regulatory Option	Annual Before-Tax Compliance Costs (excluding regulatory closures): Total Cost (millions) 1999$	Total Cost (millions) 1981$	Incremental Cost (millions) 1999$	Incremental Cost (millions) 1981$	Weighted Pollutant Removals: Total Removals (000 lbs-eq)	Incremental Removals (000 lbs-eq)	Cost-Effectiveness Ratio ($/lb-eq) 1999$	Cost-Effectiveness Ratio ($/lb-eq) 1981$
Proposed Option	1,730.1	1,009.2	1,730.1	1,009.2	9,372.3	9,372.3	185	108
Option 2/6/10	2,421.9	1,412.8	691.8	403.6	9,755.5	383.2	1,805	1,053
Option 4/8	3,795.1	2,213.8	1,373.2	801.0	9,936.9	181.4	7,570	4,416

Source: U.S. EPA analysis.

As shown in Table 4, the proposed option removes 9.4 million pounds. The proposed option is the least stringent of those considered, and the incremental cost-effectiveness for indirect dischargers is $108 per pound-equivalent removed (1981$). EPA considers this value to be acceptable when compared to values calculated for previous regulations.

Option 2/6/10 would remove an additional 0.4 million toxic weighted pounds, at an incremental cost of $0.4 billion (1981$), for a cost-effectiveness ratio of $1,000 per additional pound-equivalent removed. This cost-effectiveness value is higher than the values calculated for other industrial discharge limitations previously promulgated by EPA. The differences between the proposed option and Option 2/6/10 for indirect dischargers include the proposed option's one million gallon per year cutoff for the General Metals subcategory, two million gallon per year cutoff for the Oily Wastes subcategory, and exclusion of pretreatment standards for the Non-Chromium Anodizing, Railroad Line Maintenance and Shipbuilding Dry Dock subcategories under the MP&M rule. These provisions of the proposed rule reduce before-tax compliance costs by 29 percent compared with Option 2/6/10, while losing 4 percent of the pound-equivalents removed.

On the basis of this analysis, EPA determined that the proposed option is cost effective. The cost-effectiveness analysis supports the proposed PSES regulatory option for indirect dischargers.

Table 5 presents the results of the cost-effectiveness analysis for indirect dischargers by subcategory. The proposed option for indirect dischargers in the Printed Wiring Board, Metal Finishing Job Shop, and Steel Forming and Finishing subcategories is the same as Option 2/6/10.

The proposed option includes a flow cutoff of one million and two million gallons per year for the General Metals and Oily Wastes subcategories, respectively. Therefore, in these two subcategories, there are no proposed pretreatment standards under the MP&M rule for all indirect dischargers that fall below those cutoffs. There are also no proposed pretreatment standards for indirect dischargers in the Non Chromium Anodizing, Railroad Line Maintenance and Shipbuilding Dry Dock subcategories. (See the preamble for the proposed rule and the *Technical Development Document* for a discussion of EPA's rationale for proposing the low flow cutoffs and subcategory specific exclusions).

Table 5: Cost-Effectiveness for Indirect Dischargers by Subcategory

Subcategory & Regulatory Option	Incremental Before-Tax Compliance Cost (million 1981$)	Incremental Removals (lbs-eq)	Cost-Effectiveness Ratio (1981$/lb-eq)
Printed Wiring Boards			
Proposed Option	81.17	1,195,260	68
Option 2/6/10			
Option 4/8	40.87	8,010	5,103
Metal Finishing Job Shops			
Proposed Option	68.82	1,766,063	39
Option 2/6/10			
Option 4/8	26.54	62,554	424
General Metals			
Proposed Option	844.52	6,216,887	136
Option 2/6/10	279.12	318,594	876
Option 4/8	487.21	103,514	4,707
Non-Chromium Anodizing			
Proposed Option			
Option 2/6/10	15.23	13,598	1,120
Option 4/8	7.27	434	16,756
Oily Wastes			
Proposed Option	2.52	14,140	178
Option 2/6/10	109.04	51,008	2,138
Option 4/8	232.35	5,885	39,484
Railroad Line Maintenance			
Proposed Option			
Option 2/6/10	0.15	17	8,560
Option 4/8	0.13	132	995
Shipbuilding Dry Dock			
Proposed Option			
Option 2/6/10	0.10	0	767,794
Option 4/8	0.00	26	0
Steel Forming & Finishing			
Proposed Option	12.19	179,900	68
Option 2/6/10			
Option 4/8	6.63	865	7,659

Source: U.S. EPA analysis.

2.2 Direct Dischargers

Table 6 summarizes the cost-effectiveness for the BPT/BAT regulatory options applicable to direct dischargers. As with indirect dischargers, regulatory options are listed in order of increasing stringency, measured by toxic-weighed pollutant removals.

Table 6 shows that the proposed option achieves 1.3 million pounds of removals. The resulting cost-effectiveness is $107 per pound-equivalent (1981$). Because the only differences between Option 2/6/10 and the proposed option occur for indirects (i.e. flow cutoffs and no regulation options), Option 2/6/10 is the same as the proposed option for direct dischargers.

Option 4/8 would remove an additional 0.003 million pound equivalents, as compared with the proposed option, at an additional cost of $0.08 billion, or $2,391 per pound-equivalent.

On the basis of this analysis, EPA determines that the proposed option is cost-effective, and that the cost-effectiveness supports the choice of the proposed BPT/BAT option for direct dischargers.

Table 6: Cost-Effectiveness For Direct Dischargers (BAT)

Regulatory Option	Annual Before-Tax Compliance Costs (excluding regulatory closures)				Weighted Pollutant Removals		Cost-Effectiveness Ratio ($/lb-eq)	
	Total Cost (millions)	Total Cost (millions)	Incremental Cost (millions)		Total Removals (000 lbs-eq)	Incremental Removals (000 lbs-eq)		
	1999$	1981$	1999$	1981$			1999$	1981$
Proposed Option	245.8	143.4	245.8	143.4	1,333.6	1,333.6	184	107
Option 2/6/10	245.8	143.4			1,333.6			
Option 4/8	381.6	222.6	135.8	79.2	1,366.7	33.1	4,103	2,391

Source: U.S. EPA analysis.

Table 7 presents the results of the cost-effectiveness analysis for direct dischargers by subcategory. The proposed option is more stringent and efficient than Option 4/8 for the Oily Wastes subcategory, in that it removes more toxic weighted pounds of pollutants and costs less than Option 4/8. It therefore dominates Option 4/8 from the perspective of toxic pollutant removals, and has an average cost per pound-equivalent removed of $399.

Table 7 shows a high cost-effectiveness for the Railroad Line Maintenance and the Shipbuilding Dry Dock subcategories. EPA is not proposing BAT limitations for these subcategories because of the small quantities of toxic pollutants in the wastewater from facilities in these subcategories. However, EPA is proposing BPT limitations for these subcategories in order to control the discharge of conventional pollutants.

Table 7: Cost-Effectiveness for Direct Dischargers by Subcategory			
Subcategory & Regulatory Option	**Incremental Before-Tax Compliance Cost (million 1981$)**	**Incremental Removals (lbs-eq)**	**Cost-Effectiveness Ratio (1981$/lb-eq)**
Printed Wiring Boards			
Proposed Option	1.42	64,573	22
Option 2/6/10			
Option 4/8	1.14	2,270	501
Metal Finishing Job Shops			
Proposed Option	0.69	14,194	49
Option 2/6/10			
Option 4/8	0.52	265	1,968
General Metals			
Proposed Option	114.54	899,372	127
Option 2/6/10			
Option 4/8	52.20	21,620	2,414
Non-Chromium Anodizing[a]			
Proposed Option	NA	NA	
Option 2/6/10	NA	NA	
Option 4/8	NA	NA	
Oily Wastes			
Option 4/8	31.34	15,703	1,996
Proposed Option[b]	-24.92	366	-68,007
Option 2/6/10	0.00	0	
Railroad Line Maintenance			
Proposed Option	0.67	174	3,831
Option 2/6/10			
Option 4/8	0.05	23	2,181
Shipbuilding Dry Dock			
Proposed Option	1.24	111	11,179
Option 2/6/10			
Option 4/8	-0.91	335	-2,728
Steel Forming & Finishing			
Proposed Option	18.39	339,147	54
Option 2/6/10			
Option 4/8	1.28	8,977	143

a. EPA estimates that there are no direct discharging non-chromium anodizing facilities.
b. The proposed option has a cost-effectiveness value of 399 when compared to the baseline. This is the number that is presented in the preamble.
Source: U.S. EPA analysis.

3 Comparison with Values for Previous Effluent Guidelines and Standards

Tables 8 and 9 present, for indirect and direct dischargers respectively, the baseline and post-compliance pollutant loadings and resulting cost-effectiveness values that were calculated for previous regulations. The values for the proposed MP&M rule are also listed in these tables. All values are based on Toxic Weighting Factors normalized to copper and the cost-effectiveness values are presented in both 1981 and 1999 dollars.

Table 8: Industry Comparison of Cost-Effectiveness Values for Indirect Dischargers Toxic and Nonconventional Pollutants Only, Copper Based Weights)[a]

Industry	Pounds Equivalent Currently Discharged (To Surface Waters) (000's)	Pounds Equivalent Remaining at Selected Option (To Surface Waters) (000's)	Cost-effectiveness of Selected Option Beyond BPT ($/lb-eq. removed)	
			1981$	1999$
Aluminum Forming	1,602	18	155	267
Battery Manufacturing	1,152	5	15	26
Can Making	252	5	38	65
Centralized Waste Treatment	689	328-330	70-110	121-189
Coal Mining	N/A	N/A	N/A	N/A
Coil Coating	2,503	10	10	17
Copper Forming	934	4	10	17
Electronics I	75	35	14	24
Electronics II	260	24	14	24
Foundries	2,136	18	116	200
Inorganic Chemicals I	3,971	3,004	9	15
Inorganic Chemicals II	4,760	6	< 1	<2
Iron & Steel	5,599	1,404	6	10
Leather Tanning	16,830	1,899	111	191
Metal Finishing	11,680	755	10	17
Metal Products & Machinery[b]	**15,677**	**6,305**	**108**	**185**
Nonferrous Metals Forming	189	5	90	155
Nonferrous Metals Mfg I	3,187	19	15	26
Nonferrous Metals Mfg II	38	0.41	12	21
Organic Chemicals, Plastics...	5,210	72	34	59
Pesticide Manufacturing (1993)	257	19	18	31
Pesticide Formulating, Packaging...	7,746	112	<3	<5
Pharmaceuticals	340	63	1	2
Plastic. Molding & Forming	N/A	N/A	N/A	N/A
Porcelain Enameling	1,565	96	14	24
Pulp & Paper	9,539	103	65	112
Transportation Equipment Cleaning	38	19	380	654

a. Toxic weighting factors for priority pollutants varied across these rules. This table reflects the factors used and the resulting cost-effectiveness values at the time of regulation. Estimates of POTW removals also changed over time.
b. Proposed rule.
N/A: Pretreatment Standards not promulgated, or no incremental costs will be incurred.
Source: U.S. EPA analysis.

Table 9: Industry Comparison of Cost-Effectiveness Values for Direct Dischargers Toxic and Nonconventional Pollutants Only, Copper Based Weights)[a]

Industry	Pounds Equivalent Currently Discharged (To Surface Waters) (000's)	Pounds Equivalent Remaining at Selected Option (To Surface Waters) (000's)	Cost-effectiveness of Selected Option Beyond BPT ($/lb-eq. removed)	
			1981$	1999$
Aluminum Forming	1,340	90	121	208
Battery Manufacturing	4,126	5	2	3
Can Making	12	0.2	10	17
Centralized Waste Treatment	3,372	1,267-1,271	5-7	9-12
Coal Mining	BAT=BPT	BAT=BPT	BAT=BPT	BAT=BPT
Coastal Oil and Gas				
- Produced Water	5,998	506	3	5
- Drilling Waste	7	0	292	503
- TWC[d]	2	0	200	344
Coil Coating	2,289	9	49	84
Copper Forming	70	8	27	46
Electronics I	9	3	404	696
Electronics II	NA	NA	NA	NA
Foundries	2,308	39	84	145
Inorganic Chemicals I	32,503	1,290	< 1	<2
Inorganic Chemicals II	605	27	6	10
Iron & Steel	40,746	1,040	2	3
Leather Tanning	259	112	BAT=BPT	BAT=BPT
Metal Finishing	3,305	3,268	12	21
Metal Products & Machinery[c]	**3,103**	**1,769**	**BAT=BPT**	**BAT=BPT**
Nonferrous Metals Forming	34	2	69	118
Nonferrous Metals Mfg I	6,653	313	4	7
Nonferrous Metals Mfg II	1,004	12	6	10
Offshore Oil and Gas[b]	3,808	2,328	33	57
Organic Chemicals, Plastics...	54,225	9,735	5	9
Pesticide Manufacturing (1993)	2,461	371	15	26
Pharmaceuticals	208	4	1	2
Plastics Molding & Forming	44	41	BAT=BPT	BAT=BPT
Porcelain Enameling	1,086	63	6	10
Petroleum Refining	BAT=BPT	BAT=BPT	BAT=BPT	BAT=BPT
Pulp & Paper	61,713	2,628	39	67
Textile Mills	BAT=BPT	BAT=BPT	BAT=BPT	BAT=BPT
Transportation Equipment Cleaners	BAT=BPT 1	BAT+BPT ND	BAT=BPT 323	BAT+BPT 554

a. Toxic weighting factors for priority pollutants varied across these rule This table reflects the factors used and resulting cost-effectiveness values at the time of regulation. Estimated POTW removals have also changed over time.
b. Produced water only. For produced sand and drilling fluids and drill cuttings, BAT=BPT.
c. Proposed rule.
d. Treatment, workover, and completion fluids.
Source: U.S. EPA analysis.

4 MP&M Pollutants of Concern

Table 10 shows the 150 MP&M pollutants of concern with their CAS number, toxic weighting factor (TWF), and POTW removal percent. Nineteen of the pollutants did not appear in MP&M facility loadings and were therefore not included in the cost-effectiveness analysis.

Table 10: MP&M Pollutants of Concern

Name	CAS Number	POTW Removal Efficiency %	Toxic Weighting Factor (TWF)
Conventional Pollutants			
Bod 5-day (Carbonaceous)	C003	89.12	
Oil and Grease		88.25	
Oil and Grease (As HEM)	C036	86.08	
Total Suspended Solids	C009	89.55	
Non-Conventional Metals			
Aluminum	7429905	91.36	0.064
Gold	7440575	32.52	
Boron	7440428	30.42	0.18
Barium	7440393	15.98	0.002
Bismuth	7440699	32.52	
Calcium	7440702	8.54	0.000028
Cobalt	7440484	6.11	0.11
Iron	7439896	81.99	0.0056
Iridium	7439885	32.52	
Potassium	7440097	32.52	0.0011
Magnesium	7439954	14.14	0.00087
Manganese	7439965	35.51	0.07
Molybdenum	7439987	18.93	0.2
Sodium	7440235	2.69	0.0000055
Niobium	7440031	32.52	
Osmium	7440042	32.52	
Phosphorus	7723140	32.52	0
Silicon	7440213	32.52	
Tin	7440315	42	0.3
Strontium	7440246	32.52	0.0000082
Sulfur	7704349	32.52	0.0000056
Tantalum	7440257	32.52	0.06
Titanium	7440326	91.82	0.029
Vanadium	7440622	9.51	0.62
Tungsten	7440337	32.52	0.0053
Yttrium	7440655	32.52	

Table 10: MP&M Pollutants of Concern

Name	CAS Number	POTW Removal Efficiency %	Toxic Weighting Factor (TWF)
Non-Conventional Organics			
N,n-dimethylformamide	68122	87	0.0000079
N-decane	124185	9	0.0043
N-docosane	629970	88	0.000082
N-dodecane	112403	95.05	0.0043
N-eicosane	112958	92.4	0.0043
N-hexacosane	630013	71.11	0.000082
N-hexadecane	544763	71.11	0.0043
N-nitrosopiperidine	100754	77.32	0.00002
N-octacosane	630024	71.11	0.000082
N-octadecane	593453	71.11	0.0043
N-tetracosane	646311	71.11	0.000082
N-tetradecane	629594	71.11	0.0043
N-triacontane	638686	77.32	0.000082
O+p Xylene	136777612	65.4	0.0047
O-cresol	95487	52.5	0.0027
P-cresol	106445	71.67	0.004
P-cymene	99876	99.79	0.024
Pyridine	110861	95.4	0.0013
Styrene	100425	93.65	0.014
1,4-dioxane	123911	45.8	0.00023
Trichlorofluoromethane	75694	77.32	0.00096
Tripropyleneglycol Methyl Ether	20324338	52.4	0.0000082
M+p Xylene	179601231	77.32	0.0047
O-xylene	95476	77.32	0.0043
1-bromo-2-chlorobenzene	694804	77.32	0.0047
1-bromo-3-chlorobenzene	108372	77.32	0.0082
1-methylfluorene	1730376	84.55	0.049
1-methylphenanthrene	832699	84.55	0.1
2-butanone	78933	96.6	0.000025
2-hexanone	591786	77.32	0.00023
2-isopropylnaphthalene	2027170	77.32	0.072
2-methylnaphthalene	91576	28	0.08
2-propanone	67641	83.75	0.000005
3,6-dimethylphenanthrene	1576676	84.55	0.27
4-methyl-2-pentanone	108101	87.87	0.00013
Acetophenone	98862	95.34	0.00024
Alpha-terpineol	98555	94.4	0.0011
Aniline	62533	93.41	1.4

Table 10: MP&M Pollutants of Concern

Name	CAS Number	POTW Removal Efficiency %	Toxic Weighting Factor (TWF)
Benzoic Acid	65850	80.5	0.00033
Benzyl Alcohol	100516	78	0.0056
Biphenyl	92524	96.28	0.029
Carbon Disulfide	75150	84	2.8
Dibenzofuran	132649	77.32	0.2
Dibenzothiophene	132650	84.68	0.046
Diphenyl Ether	101848	77.32	
Diphenylamine	122394	77.32	0.013
Hexanoic Acid	142621	84	0.00037
Isobutyl Alcohol	78831	28	0.0014
M-xylene	108383	95.07	0.0015
Methyl Methacrylate	80626	99.96	0.0003
Other Non-Conventional Pollutants			
Acidity			
Amenable Cyanide	C025	57.41	
Total Alkalinity			
Chloride	16887006	57.41	0.000024
Chemical Oxygen Demand (COD)	C004	81.3	
Hexavalent Chromium	18540299	57.41	0.51
Fluoride	16984488	61.35	0.035
Total Fluoride		57.41	
Ammonia as Nitrogen	7664417	38.94	0.0025
Total Phosphorus	14265442	57.41	
Sulfate	14808798	84.61	0.0000056
Total Petroleum Hydrocarbons (As Sgt-HEM)	C037	57.41	
Total Sulfide	18496258	57.41	2.8
Total Dissolved Solids	C010	8	
Total Kjeldahl Nitrogen	C021	57.41	
Total Organic Carbon (TOC)	C012	70.28	
Total Recoverable Phenolics	C020	57.41	
Weak-acid Dissociable Cyanide	C042		
Priority Pollutant Metals			
Silver	7440224	88.28	16
Arsenic	7440382	65.77	3.5
Beryllium	7440417	71.66	1.1
Cadmium	7440439	90.05	2.6
Cyanide	57125	70.44	1.1
Chromium	7440473	80.33	0.076
Copper	7440508	84.2	0.63

Table 10: MP&M Pollutants of Concern			
Name	**CAS Number**	**POTW Removal Efficiency %**	**Toxic Weighting Factor (TWF)**
Mercury	7439976	71.66	120
Nickel	7440020	51.44	0.11
Lead	7439921	77.45	2.2
Antimony	7440360	66.78	0.0048
Selenium	7782492	34.33	1.1
Thallium	7440280	71.66	1
Zinc	7440666	79.14	0.047
Priority Pollutant Organics			
Acenaphthene	83329	98.29	0.029
1,1,1-trichloroethane	71556	90.45	0.0045
1,1-dichloroethane	75343	70	0.00039
1,1,2,2-tetrachloroethane	79345	77.51	0.053
Chloroethane	75003	77.51	0.0014
Acrolein	107028	77.51	0.97
4-chloro-3-methylphenol	59507	63	0.0043
Chloroform	67663	73.44	0.0021
1,2-dichlorobenzene	95501	77.51	0.011
1,1-dichloroethene	75354	77.51	0.18
2,4-dimethylphenol	105679	77.51	0.0053
2,6-dinitrotoluene	606202	77.51	0.1
Ethylbenzene	100414	93.79	0.0014
Fluoranthene	206440	42.46	0.8
Benzene	71432	77.51	0.018
Methylene Chloride	75092	54.28	0.00042
Chloromethane	74873	69.74	0.0021
Isophorone	78591	77.51	0.00073
Naphthalene	91203	94.69	0.015
2-nitrophenol	88755	26.83	0.0016
4-nitrophenol	100027	77.51	0.0094
2,4-dinitrophenol	51285	77.51	0.0075
N-nitrosodimethylamine	62759	77.51	0.07
N-nitrosodiphenylamine	86306	90.11	0.04
Phenol	108952	95.25	0.028
Bis(2-ethylhexyl) Phthalate	117817	59.78	0.095
Butyl Benzyl Phthalate	85687	81.65	0.023
Di-n-butyl Phthalate	84742	84.66	0.012
Di-n-octyl Phthalate	117840	68.43	0.22
Chlorobenzene	108907	96.37	0.0029
Dimethyl Phthalate	131113	77.51	0.0033

Table 10: MP&M Pollutants of Concern			
Name	**CAS Number**	**POTW Removal Efficiency %**	**Toxic Weighting Factor (TWF)**
Anthracene	120127	77.51	2.5
Fluorene	86737	69.85	0.7
Phenanthrene	85018	94.89	0.29
Pyrene	129000	83.9	0.11
Tetrachloroethene	127184	84.61	0.013
Toluene	108883	96.18	0.0056
Trichloroethene	79016	77.51	0.0064

GLOSSARY

at-stream: As discharged to surface waters, after POTW treatment in the case of indirect dischargers.

Best Available Technology Economically Achievable: Effluent limitations for direct dischargers, addressing priority and non-conventional pollutants. BAT is based on the best existing economically achievable performance of plants in the industrial subcategory or category. Factors considered in assessing BAT include the cost of achieving BAT effluent reductions, the age of equipment and facilities involved, the processes employed, engineering aspects of the control technology, potential process changes, non-water quality environmental impacts (including energy requirements), economic achievability, and such factors as the Administrator deems appropriate. The Agency may base BAT limitations upon effluent reductions attainable through changes in a facility's processes and operations. Where existing performance is uniformly inadequate, EPA may base BAT upon technology transferred from a different subcategory within an industry or from another industrial category.

Best Practicable Control: Effluent limitations for direct discharging facilities, addressing conventional, toxic, and non-conventional pollutants. In specifying BPT, EPA considers the cost of achieving effluent reductions in relation to the effluent reduction benefits. The Agency also considers the age of the equipment and facilities, the processes employed and any required process changes, engineering aspects of the control technologies, non-water quality environmental impacts (including energy requirements), and such other factors as the Agency deems appropriate. Limitations are traditionally based on the average of the best performances of facilities within the industry of various ages, sizes, processes, or other common characteristics. Where existing performance is uniformly inadequate, EPA may require higher levels of control than currently in place in an industrial category if the Agency determines that the technology can be practically applied.

biochemical oxygen demand: The amount of dissolved oxygen consumed by microorganisms as they decompose organic material in an aquatic environment.

biosolids: nutrient-rich organic materials resulting from the treatment of sewage sludge

chemical oxygen demand: A measure of the oxygen required to oxidize all compounds, both organic and inorganic, in water. (http://www.epa.gov/OCEPAterms/cterms.html)

conventional pollutants: Statutorily listed pollutants understood well by scientists. These may be in the form of organic waste, sediment, acid, bacteria, viruses, nutrients, oil and grease, or heat. (http://www.epa.gov/OCEPAterms)

end of pipe: As discharged from the source outfall to surface waters (for direct dischargers) or to sewers (for indirect dischargers.

interference: The obstruction of a routine treatment process of POTWs that is caused by the presence of high levels of toxics, such as metals and cyanide in wastewater discharges. These toxic pollutants kill bacteria used for microbial degradation during wastewater treatment.

oil and grease: These organic substances may include hydrocarbons, fats, oils, waxes and high-molecular fatty acids. Oil and grease may produce sludge solids that are difficult to process. (http://www.epa.gov/owmitnet/reg.htm)

pass through: Pollutants “pass through” a POTW if they are not removed by treatment and are present in the POTW’s discharges to waters of the U.S. EPA compares the percentage of a pollutant removed by well-operated POTWs achieving secondary treatment with the percentage of the pollutant removed by facilities meeting BAT effluent limitations. For purposes of defining PSES and PSNS, a pollutant is determined to pass through if the median percentage removed by a well-operated POTW is less than the median percentage removed under BAT limitations.

Pretreatment Standards for Existing Sources: Categorical pretreatment standards for existing indirect dischargers, designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Standards are technology-based and analogous to BAT effluent limitations guidelines.

publicly-owned treatment works: A treatment works, as defined by section 212 of the Clean Water Act, that is owned by a State or municipality. This definition includes any devices or systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. It also includes sewers, pipes, or other conveyances only if they convey wastewater to a POTW Treatment Plant. (http://www.epa.gov/owm/permits/pretreat/final99.pdf)

total suspended solids: A measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids." (http://www.epa.gov/OCEPAterms/tterms.html).

toxic pound-equivalent: Pound of pollutant weighted by the pollutants toxic weighting factor, to provide a comparable toxicity-adjusted measure of pollutants discharged or removed by treatment or pollution prevention.

toxic weighting factor: A factor that measures the toxicity of a given pollutant relative to the toxicity of copper, where toxicity is assessed based on chronic freshwater aquatic criteria (or toxic effects levels) and on human health criteria (or toxic effects levels) for the consumption of fish.

Acronyms

BAT: Best Available Technology Economically Achievable
BOD: biochemical oxygen demand
BPT: Best Practicable Control
CCI: *Engineering News-Record* Construction Cost Index
COD: chemical oxygen demand
MP&M: Metal Products and Machinery
POTW: publically owned treatment works
TSS: total suspended solids
TWF: toxic weighting factor

References

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Appendix A: Alternative CE Measures

Introduction

This appendix provides two alternative measures of cost-effectiveness:

- Cost-effectiveness including costs to closing facilities; and

- Cost-effectiveness to industry

A.1 CE including costs to closing facilities.

The traditional calculation of cost-effectiveness values includes reductions in loadings that occur when facilities close due to the rule, along with reductions achieved by pollution prevention and treatment, but does not include costs for facilities that close. An alternative measure, presented in this appendix, attributes costs to the facilities that close due to the rule.

This cost-effectiveness measure includes costs for facilities that close due to the rule equal to the compliance costs they would have incurred if they instead continued to operate. This calculation overstates costs because these facilities are expected to find it more economic to shut down rather than incur the compliance costs. No costs or loadings reductions from facilities that close in the baseline are included in the analysis, as in the traditional analysis.

The following tables present the values for this alternative cost-effectiveness measure for the proposed rule by subcategory, and compares the results with the traditional measures presented in the report, for indirect and direct dischargers respectively. Table A.1 and A.2 present this comparison for indirect and direct dischargers, respectively.

Table A.1: Cost-Effectiveness for Indirect Dischargers by Subcategory With and Without Costs for Regulatory Closures

Subcategory	Removals, lb-eq	Without Costs for Regulatory Closures		With Costs for Regulatory Closures	
		Costs (millions of 1981$)	Cost-Effectiveness Ratio, $/lb-eq	Costs (millions of 1981$)	Cost-Effectiveness Ratio, $/lb-eq
General Metals	6,216,887	844.52	136	848.40	136
Metal Finishing Job Shop	1,766,063	68.82	39	87.02	49
Non-Chromium Anodizing					
Printed Wiring Board	1,195,260	81.17	68	84.89	71
Steel Forming & Finishing	179,900	12.19	68	13.66	76
Oily Wastes	14,140	2.52	178	4.94	350
Railroad Line Maintenance					
Shipbuilding Dry Dock					
Total	9,372,250	1,009.22	108	1,038.92	111

Source: U.S. EPA analysis.

Table A.2: Cost-Effectiveness for Direct Dischargers by Subcategory With and Without Costs of Regulatory Closures

Subcategory	Removals, lb-eq	Without Costs for Regulatory Closures		With Costs for Regulatory Closures	
		Costs (millions of 1981$)	Cost-Effectiveness Ratio, $/lb-eq	Costs (millions of 1981$)	Cost-Effectiveness Ratio, $/lb-eq
General Metals	899,372	114.54	127	118.60	132
Metal Finishing Job Shop	14,194	0.69	49	0.69	49
Non-Chromium Anodizing					
Printed Wiring Board	64,573	1.42	22	1.42	22
Steel Forming & Finishing	339,147	18.39	54	18.39	54
Oily Wastes	16,070	6.42	400	6.42	400
Railroad Line Maintenance	174	0.67	3,851	0.67	3,851
Shipbuilding Dry Dock	111	1.24	11,171	1.24	11,171
Total	1,333,642	143.37	108	147.42	111

Source: U.S. EPA analysis.

A.2 CE TO INDUSTRY

This section presents the incremental costs to industry per pound of pollutants removed, and cost-effectiveness values based on those costs to industry. These costs are the after-tax compliance costs as incurred by the regulated facilities. The costs exclude costs for both baseline and regulatory closures, and are annualized at 7 percent. Tables A.3 and A.4 present the results for indirect and direct dischargers, respectively.

Table A.3: Industry Cost-Effectiveness for Indirect Dischargers (PSES)

Regulatory Option	Annual After-Tax Compliance Costs (excluding regulatory closures)				Weighted Pollutant Removals		Cost-Effectiveness Ratio ($/lb-eq)	
	Total Cost (millions)		Incremental Cost (millions)		Total Removals (000 lbs-eq)	Incremental Removals (000 lbs-eq)		
	1999$	1981$	1999$	1981$			1999$	1981$
Proposed Option	1,161.7	677.7	1,161.7	677.7	9,372.3	9,372.3	124	72
Option 2/6/10	1,645.0	959.6	483.3	281.9	9,755.5	383.2	1,261	736
Option 4/8	2,644.5	1,542.6	999.5	583.0	9,936.9	181.4	5,510	3,214

Source: U.S. EPA analysis.

Table A.4: Industry Cost-Effectiveness for Direct Dischargers (BAT)

Regulatory Option	Annual After-Tax Compliance Costs (excluding regulatory closures)				Weighted Pollutant Removals		Cost-Effectiveness Ratio ($/lb-eq)	
	Total Cost (millions)		Incremental Cost (millions)		Total Removals (000 lbs-eq)	Incremental Removals (000 lbs-eq)		
	1999$	1981$	1999$	1981$			1999$	1981$
Proposed Option	167.3	97.6	167.3	97.6	1,333.6	1,333.6	125	73
Option 2/6/10	167.3	97.6			1,333.6			
Option 4/8	273.7	159.7	106.4	62.1	1,366.7	33.1	3,215	1,876

Source: U.S. EPA analysis.